Calculation of marginal size:

$$\sigma_{design} = \frac{\sigma_y}{1.5}$$ for ductile material (under bending or tensi

or $$\sigma_{design} = \frac{\sigma_u}{3}$$ for brittle material (under bending or tension)

P_{design} = Design load.
= Load x relevant load factor

The calculated size is considered the min. size that can be used.

Allowance should be made for:

- Undercuts
- Change in surface quality
- provisions for mounting other components.

Then: For static loading:

$$\text{Working stress} = \frac{\text{Actual Load (working Load)}}{\text{Adopted size cross section property}}$$

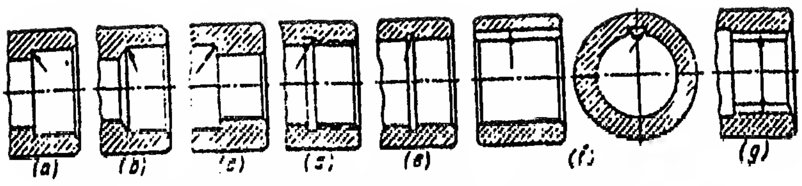
(and considering stress concentration factor if any)

$$\text{Working safety factor} = \frac{\text{Relevant Char. stress}}{\text{Working stress}}$$

Load Factor

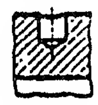
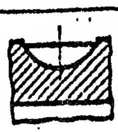
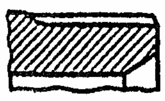
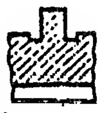
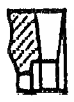
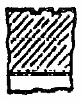
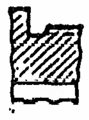
Loading condition	Load factor
– Manual operation	1.5
– Electric motor as a prime mover	
• Direct on line connection	2
• Star / Delta (Y/Δ) connection	$\sqrt{3}$
• Soft starter (Cent. Coupling, clutch, hyd. Coupling	1.5
– Pressure Cyl. and pipes	
• Unfired	1.5
• fired	2
– Testing of cranes and hoists:	
• Static test (limit deflection $\leq \frac{1}{300}$ span)	1.4
• Dynamic test	1.25
– static Load	1.0

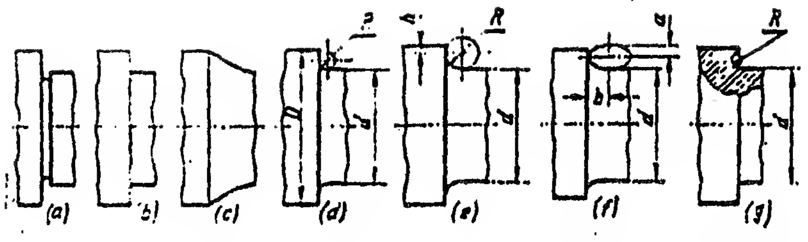
Selected Material:		Brittel	Ductile
* Characteristics considered for design according to type of load:	— Static	σ_{ut} (bending stress)	σ_y or $\sigma_{0.2\%}$ τ_y
	— Dynamic		
	• Completly reversed	σ_{en}	
	• general: Pulsating Alternating	σ_{ut} σ_{end} $(\tau \simeq 0.6\sigma)$	σ_{yt} σ_{end}
* Margin of safety:		$2.5 \rightarrow 3$	$1.3 \rightarrow 1.5$
* Stress concentration under static load:	– for material structure	$1.25 \rightarrow 1.5$	1.0
	– for geometry	Tables	



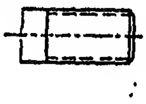
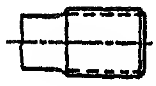
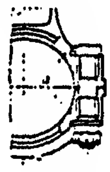
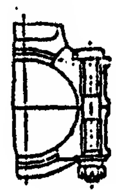
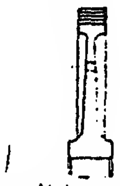
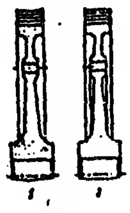
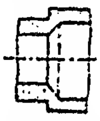
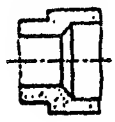
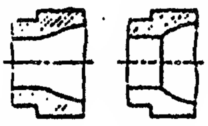
Stress concentrators in hollow shafts (indicated by arrows)

Stress Concentrators

Sketch	Concentrators	Sketch	Concentrators	Sketch	Concentrators
	Shallow drilled holes		Annular recesses		Keyseats
			Grooves		
			Sharp-angled steps		Splines
	Holes		Undercuts		Tooth spaces
					End-face slots
	Threaded holes		Flats		Welds
			Threads		Marks
					



Decreasing stress concentrations in the entry angles of stepped shafts

Original design	Improvement	Essence of improvement
Screwed rod 		Screwed portion enlarged
Conrod big end  At positions a the part is weakened by bolt head and nut recesses		Sectional areas of weakened portions enlarged
Turbine rotor  Rotor disk weakened by relieving holes		1. Holes strengthened with bosses 2. Holes positioned in a strengthening ring
Hollow shaft 		Internal stress concentrator moved
Two concentrators combine (external and internal entering angles)		Internal angles given smooth streamlined forms

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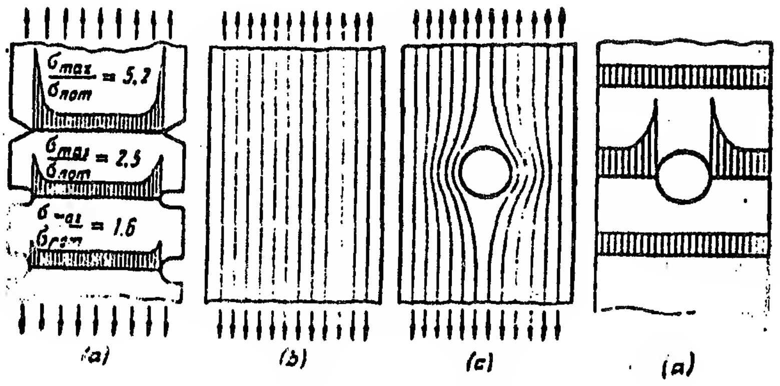
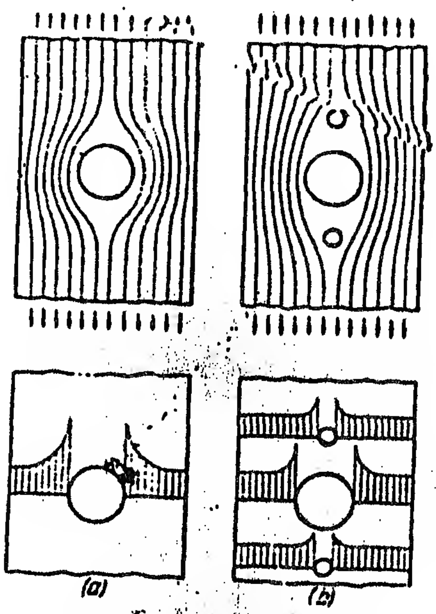
Design Considerations

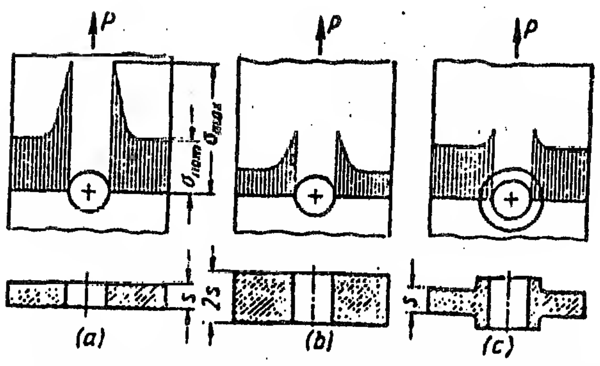
1. Stress Concentration Considerations:



Force flow in a part undergoing tension



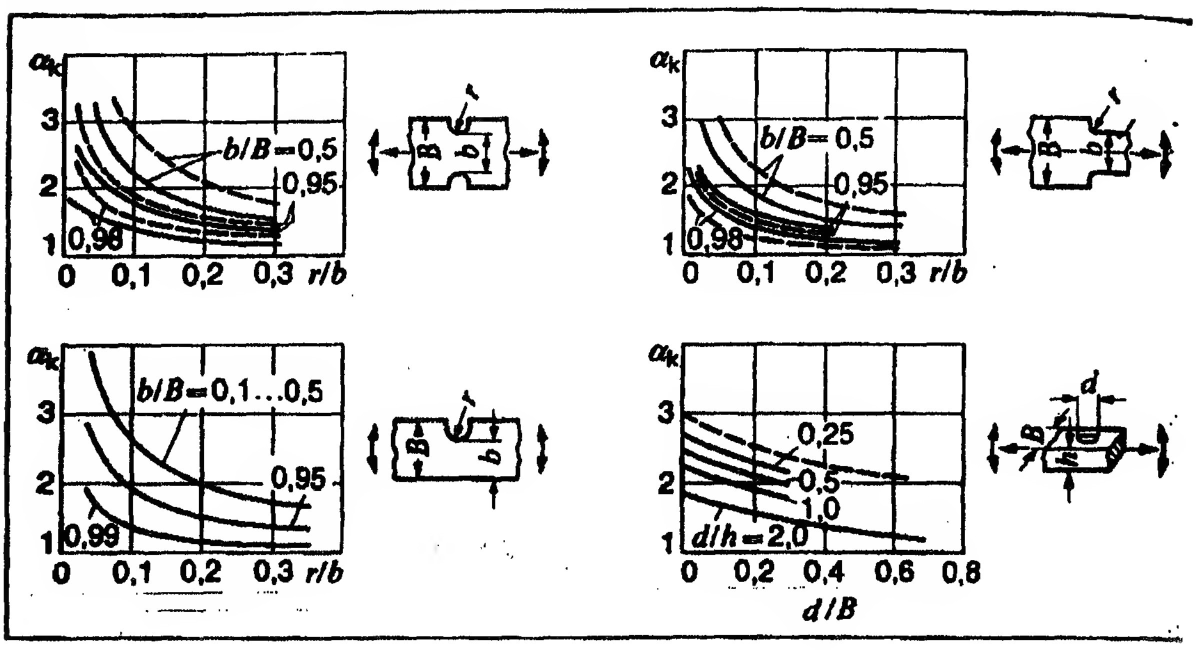
Force flow in parts
(a) with a stress concentrator (hole); (b) with stress deconcentrators



Decreasing the maximum stress by lowering the nominal stress

Stress concentration factor α_k for various notch configurations

Stress Concentration Factors for Flat Bars



Stress Concentration Factors for Rods